UNITED STATES
DEPARTMENT OF AGRICULTURE
DEPARTMENT CIRCULAR 389

Washington, D. C. | July, 1926

PROXIMATE COMPOSITION OF BEEF

CHARLOTTE CHATFIELD

Associate Home Economics Specialist, Bureau of Home Economics

CONTENTS

The proximate composition of meat is a matter of interest to every one who is concerned with the nutritive value and relative economy of the various cuts. More particularly it is of interest to doctors, hospital dietitians, and others who are responsible for the treatment of special diet cases, and to persons engaged in research in foods and nutrition or in animal production. Food composition tables available in the past have been unsatisfactory for the specialist or the investigator who wants a close estimate of the composition of a given cut of meat without chemical analysis.

The present study was undertaken for the purpose of revising the meat section of the bulletin of Atwater and Bryant (*1*),[1] and has been carried on in close cooperation with specialists from the Bureau of Animal Industry and the Bureau of Agricultural Economics.

The bulletin of Atwater and Bryant has provided the basis for most dietary calculations in this country. The tables were made by averaging, in groups, all of the analyses available in 1899 when the bulletin was last revised. With the data now available, and with an improved method of handling them it has been possible to derive figures that correspond with the commercial grades and permit of much greater accuracy in estimating the composition of particular cuts of beef.

Beef is extremely variable in its composition. The lean meat from the round of a thin carcass may have only 2 per cent fat, as ether extract, whereas the visible fat from the loin of a fat carcass may have as much as 89 per cent. The wholesale rib on the butcher's block may have anywhere from 7 to 60 per cent of fat in its entire edible portion, or in other words may vary from 650 to 2,590 in the calories it will yield per pound of edible meat. These facts suggest

[1] Reference is made by number (italic) to "Literature cited," p. 18.

99059°—26——1

the difficulty of making a simple, satisfactory classification for the different cuts of beef and of giving adequate figures on the composition of each class.

SELECTION AND CLASSIFICATION OF DATA

An attempt has been made to collect all of the data in this country, both published and unpublished, on the physical and chemical composition of beef, and to select from these everything that is reported on a basis suitable for use in this study. Unfortunately a large number of these data had to be discarded because the inedible portions had been included with the edible in the samples analyzed. For the cuts of beef no data were used except from those which conform approximately to the current standard practice of cutting (*2*). All beef that would have been graded below "common" and, excepting the carcass from one animal, any beef that was slaughtered under 11 months of age was ruled out. This one animal was over 8 months old. Too few analyses of animals younger than 11 months could be found to permit of deriving reliable figures for the composition of such beef.

The principal sources of published data are bulletins and reports from the Missouri, Illinois, and Maine Agricultural Experiment Stations (*4, 6, 7, 9, 10, 11, 12, 16, 17*). Unpublished data have been contributed by the Office of the Surgeon General, United States Army, from work done under R. D. Milner. The compilation includes also figures from a few of the analyses made under Atwater's direction, and included in the bulletin under revision. From these sources there were 54 analyses of sides, or carcasses, given on a basis that could be used. Four classes by fat content and class limits for sides were chosen to correspond as closely as possible to the commercial grades as shown in Table 1.

TABLE 1.—*Classification of beef sides by fatness*

Class	Commercial grades	Fat (as ether extract) in the edible portion
		Per cent
Thin	Common	8 to 18
Medium	Medium	18 to 25
Fat	Good	25 to 35
Very fat	Choice and prime	35 or over

These limits of fat content were selected after careful consideration of the data and consultation with specialists in this department who are experienced in grading meat. The "edible portion," consisting of the lean meat and the visible fat, was used as the basis for all classification and calculation except in the case of percentage of bone.

The analyses for wholesale cuts from these sides and from a few others were used if the evidence seemed to indicate that they had been cut according to the basis adopted. Such evidence consisted of cutting diagrams, descriptions of the way the carcass was divided, figures for the weight of the cuts in terms of percentage of the carcass, or a combination of these data. With the exception of two cases, in which only one composite sample of edible fat from each side was analyzed, no anaylses were included unless the entire wholesale cut had been sampled.

CALCULATION OF TYPICAL FIGURES FOR PERCENTAGE OF FAT

The figures for sides were examined after they had been classified to decide whether the 54 carcasses could be regarded as being fairly typical of all beef in the way that they were distributed with respect to fat content. As an estimate of the way the general run of domestic beef falls into commercial grades, the figures of Davis and Whalin (3) have been used. According to these authors the distribution by

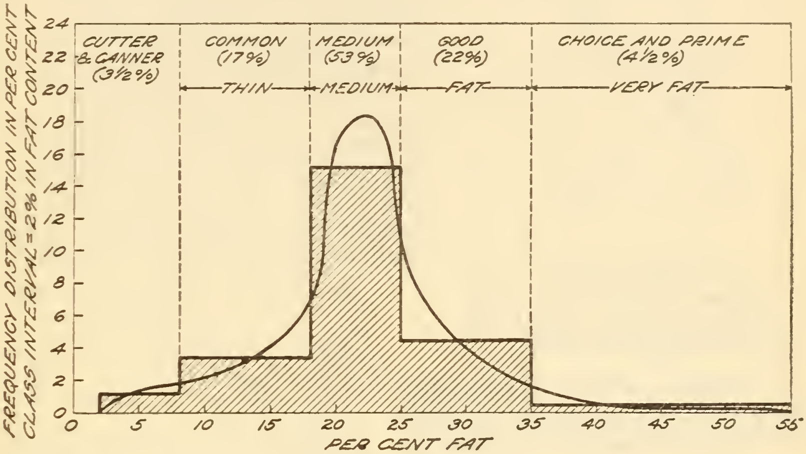

FIG. 1.—Frequency distribution of beef carcasses by fat content of the edible portion estimated from distribution by commercial grades

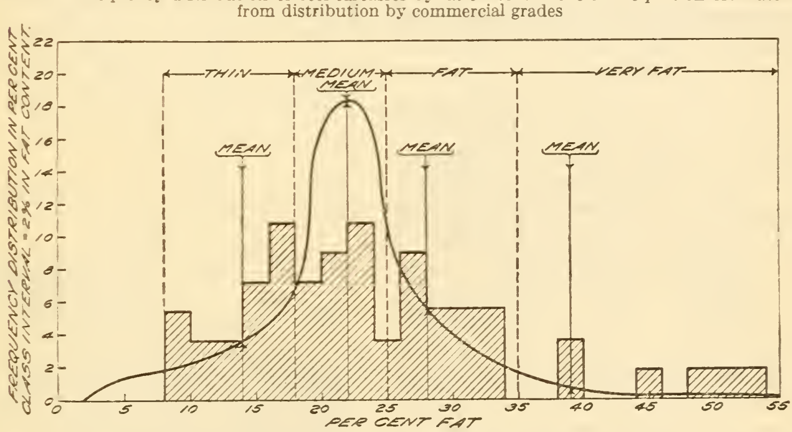

FIG. 2.—Distribution by fat content of all beef [estimated] as compared with the distribution of the 54 carcasses analyzed. This group of 54 excludes carcasses having less than 8 per cent fat in the edible portion and is considered to represent 96.5 per cent of all beef carcasses. The derived mean for each class is indicated. The bias of the small number is particularly apparent in the very fat class

grades of steers including Corn Belt and range types received at the Chicago market over a period of one year was as follows: Cutter and canner, 3.5 per cent; common, 17; medium, 53; good, 22; and choice and prime, 4.5. Assuming that these percentages apply approximately to the corresponding classes under consideration, a histogram of the frequency distribution by fat content was made (fig. 1). From this a distribution curve that is a modification of a normal curve was assumed. It was drawn in such a way that the area under the curve was the same in each of the classes as the corresponding area in the

histogram. This curve is a rough estimate of the actual frequency distribution by fatness of beef carcasses in general. Obviously it is a closer estimate, however, of what is typical in a given class than any that could be obtained from the data on the 54 carcasses analyzed. The data used in deriving the curve were taken from a very large number of animals selected to represent market beef, whereas the 54 carcasses were selected in such a way as to give a distinct bias in the matter of distribution. In Figure 2, the distribution of the 54 carcasses is shown in a histogram to compare with the assumed distribution curve. It is apparent that the distribution of the smaller number could not be typical of beef in general.

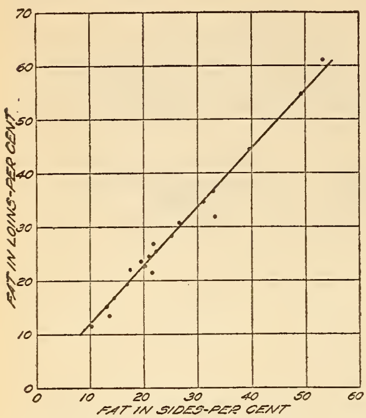

FIG. 3.—Relation of fat content (ether extract) of the edible portion (composite lean and fats of the whole loin to that of the side. Dot) represent averages of three analyses

An estimate of the average fatness of each class of beef was made by dividing perpendicularly the area representing each class under the distribution curve so that half of the area in that class lay on either side of the dividing line (fig. 2). This was done from the assumed distribution curve in an attempt to approach a median or average point in percentage of fat in a very large number of carcasses or in all beef of its class, rather than in the small number of that class which happened to have been chosen for chemical analysis. This division was made to the nearest percentage of fat, and the resulting figure was used as the average representing its class. These derived figures for average percentage of fat as ether extract in the edible portion of the sides compared with the straight averages of the small number as shown in Table 2.

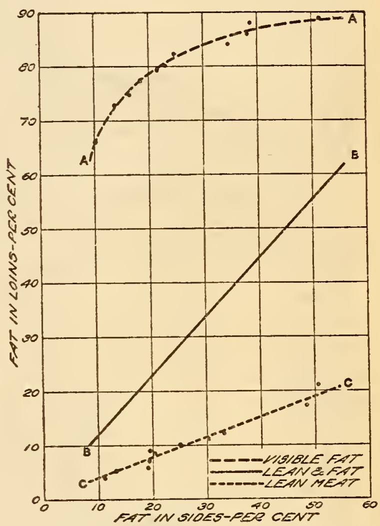

FIG. 4.—Relation of the fat content (ether extract) of the visible fat (A) and of the lean meat (C) of the whole loin to the fat content of the side. The curve for composite lean and fat (B) is identical with the curve in Figure 3 and is included here for comparison. Dots represent averages of three analyses

TABLE 2.—*Average fat (ether extract) content of beef sides by classes*

Class	Straight averages of sides analyzed chemically	Derived averages
	Per cent	*Per cent*
Thin	14.0	14
Medium	21.4	22
Fat	29.1	28
Very fat	46.6	39

The average fatness and the class limits were determined for the wholesale cuts from curves which relate fatness of side to that of cut. The curve for loin is illustrated in Figure 3. In the work reported by the Missouri and Illinois stations the lean meat and the visible fat were separated by dissection, and in the case of some cuts, particularly loin, rib, and round, numerous analyses of these portions were available. The technique of this separation is described in the bulletins of those stations. Separate curves were drawn, therefore, for the lean and the visible fat of certain cuts (fig. 4). This procedure established for each cut the average percentage of fat in each class on the basis of the composite of the edible portion, and for several on that of the lean meat and the visible fat separately. The percentages of fat in the cut were read directly from the derived averages of percentage of fat in the sides. The figures obtained by this method for the composite lean and fat of the edible portion of the loin as compared with the ones for sides are given in Table 3.

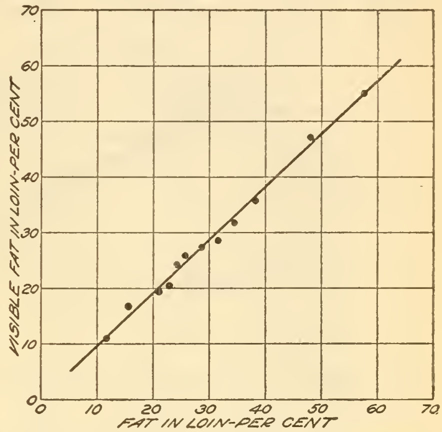

FIG. 5.—Relation of content of visible fat to that of fat (ether extract) in the edible poriton of the whole loin. The range of variation is narrow and therefore the error of estimation is small. Dots represent averages of three analyses

TABLE 3.—*Fat content of the edible portion of beef sides and of loin, by classes*

Class	Fat (ether extract) in sides		Fat (ether extract) in loin		Visible fat in loin
	Averages	Class limits	Averages	Class limits	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Thin	14	8 to 18	16	10 to 21	15
Medium	22	18 to 25	25	21 to 28	24
Fat	28	25 to 35	31	28 to 39	29
Very fat	39	35 or over	43	39 or over	41

The relation between the percentage of fat (ether extract) and of visible fat was determined graphically for the edible portion of the sides and of each wholesale cut. For any given wholesale cut the relationship is close, but the cuts are not alike in this. In the loin 50 per cent of visible fat corresponds to 53 per cent of ether extract, but in the flank the same percentage of visible fat corresponds to 41 per cent, and in the rib to 56 per cent of ether extract. This disparity necessitated the use of separate estimating curves. The curve for loin is shown in Figure 5. It is apparent that estimates based on these curves are fairly reliable for wholesale cuts because of the close agreement between the observations. The use of these estimates is discussed later in connection with the interpretation of Table 7. The figures for the visible fat in the loin for the four classes of beef are shown in the last column of Table 3. These estimates relate to the fat content only. The protein, ash, and water content were estimated by another set of curves.

ESTIMATION OF PROTEIN, ASH, AND WATER

The next step was a correlation between the fat and the crude protein (N×6.25) and another between the fat and the ash. The water, being for the present purpose relatively unimportant except in the original analysis as a check on the other constituents, was

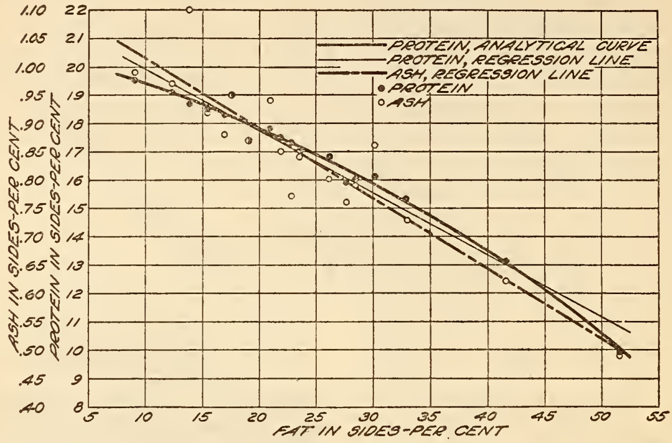

FIG. 6.—Relation of content of protein and ash to that of fat (ether extract) in the edible portion of the sides. Dots represent averages of three analyses

taken by difference (100 per cent minus percentage of protein, fat, and ash).

Rubner (*13*) and Moulton (*8*) have called attention to the fact that on the "fat-free" basis the tissues of mature animals of various species have a relatively constant composition regardless of the

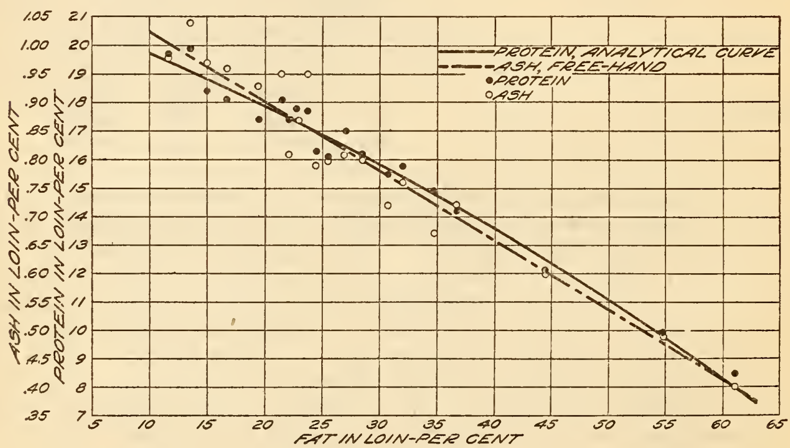

FIG. 7.—Relation of content of protein and ash to that of fat (ether extract) in the edible portion of the whole loin. Dots represent averages of three analyses

degree of fatness or the age of the animal. Their work was based on analyses of the whole animal including the bone and other inedible portions and not on separate tissues. The present study has shown further that when allowance is made for the content of fat, the

difference in composition between the various wholesale cuts as based on the edible portion is measurable but not very wide.

If it could be assumed that the variation in composition on a "fat-free" basis is negligible, a single straight line curve relating protein to fat and another relating ash to fat could be used to estimate these constituents in all of the cuts. It was found, however, that there is a small but appreciable variation in the composition of beef of various degrees of fatness, even on a "fat-free" basis, as well as a variation between the various cuts. For this reason separate estimating curves were used for the sides and for each of the wholesale cuts.

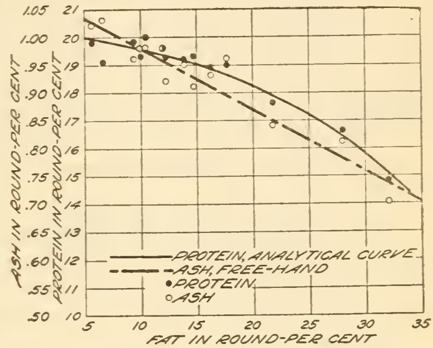

FIG. 8.—Relation of content of protein and ash to that of fat (ether extract) in the edible portion of the round. Dots represent averages of three analyses

Several of these estimating curves are given in Figures 6, 7, 8, and 9. Protein and ash are plotted against fat. For protein, either analytical or free-hand curves were used where the relation was definitely curvilinear. Some of these curves were drawn from the plotted points by inspection. Where straight lines were used, they were derived in a few cases from regression equations.

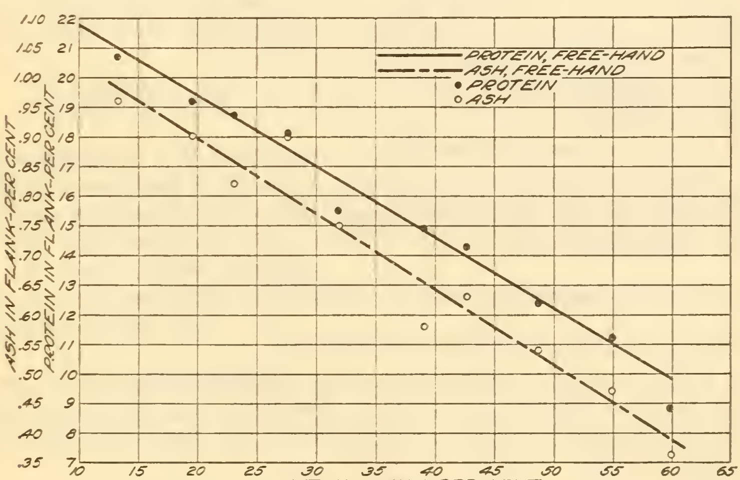

FIG. 9.—Relation of content of protein and ash to that of fat (ether extract) in the edible portion of the flank. Analyses of flanks from which the cod fat had been removed are included with others of the entire wholesale cut of flank. Dots represent averages of three analyses

Gross linear correlations (Pearsonian) were calculated between the protein and fat, and the ash and fat for the edible portion, lean and fat, of the entire side; the lean meat from certain cuts, principally loin, rib, and round; and the visible fat from the same cuts. The coefficients of correlation and the standard errors of estimate are given in Table 4.

TABLE 4.—*Coefficients of correlation between protein and fat and between ash and fat and standard errors of estimate*

	Protein to fat		Ash to fat	
	Coefficient	Standard error [1]	Coefficient	Standard error [1]
		Per cent		*Per cent*
Sides	−0.96	0.64	−0.84	0.083
Lean meat	−0.74	0.69	−0.77	0.051
Visible fat	−0.92	1.06	−0.85	0.058

[1] Standard errors are expressed in the same units as the original estimates—that is, in percentage of edible portion.

The regression lines from these correlations are shown in Figures 6, 10, and 11. It appears from the diagrams that the relation of protein to fat is curvilinear in the cases of the sides and the "lean meat;" in the case of the "visible fat," on the other hand, the straight line is a close fit.

Estimating curves for protein in the sides and for some of the cuts were plotted according to points calculated from the sums of decreasing geometric series. Spillman (*14, 15*) has shown that the increments in a large number of growth curves take the form of such a series, and this suggested the possibility that the relation of protein to fat might also be estimated by a curve of the formula

$$Y = a + \frac{b(1-R^x)}{1-R}$$

in which Y is the percentage of protein, a and b are constants, R is the constant ratio between the terms of the geometric series, and x is a function of the percentage of fat. In the formula used for protein in the sides, $a = 10.58$, $b = 2.92$, $R = 0.815$, and $x = \frac{50 - \text{percentage of fat}}{10}$

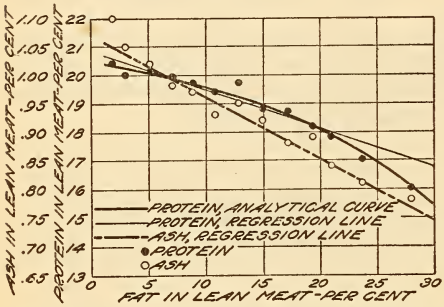

FIG. 10.—Relation of content of protein and ash to that of fat (ether extract) in the lean meat from certain cuts, principally loin, rib, and round. Dots represent averages of unequal numbers of analyses. The total number of analyses included is 118

The data in Table 5 show the calculated percentage of protein for each designated percentage of fat in the sides and illustrate the fact that the increases in protein correspond to the terms of a decreasing geometric series.

TABLE 5.—*Estimation of protein from fat content in sides*

Fat	Protein	Increase in protein
Per cent	*Per cent*	*Per cent*
50	10.58	----------
40	13.50	2.92
30	15.88	2.38
20	17.82	1.94
10	19.40	1.58

The ratio of each increase in the percentage of protein to the preceding one is constant, for example, in this table

$$R=\frac{2.38}{2.92}=\frac{1.94}{2.38}=\frac{1.58}{1.94}=0.815.$$

Using this formula for protein gave an index of correlation of 0.97 and a standard error of estimate of 0.55 per cent as compared with a coefficient of 0.96 and a standard error of 0.64 per cent for linear correlation. For some of the cuts the protein curve had greater curvature than that of the one for sides, and in these cases the advantage of the curve over the straight line was even greater.

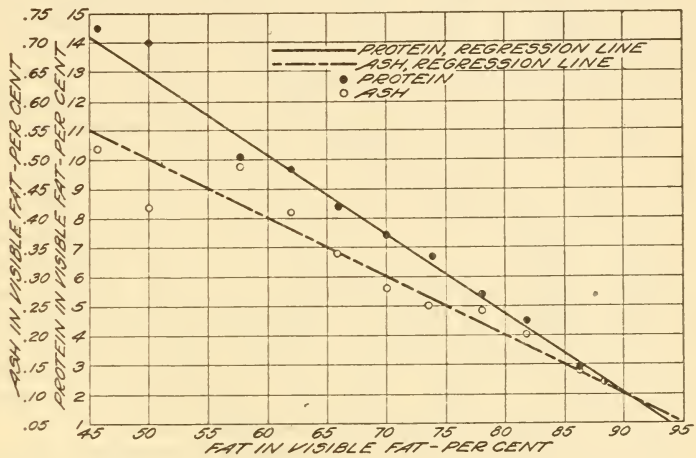

FIG. 11.—Relation of content of protein and ash to that of fat (ether extract) in the visible fat from certain cuts, principally loin, rib, and round. Dots represent averages of unequal numbers of analyses. The total number of analyses included is 118

As a further evidence of the accuracy of estimation by this formula, straight averages for the protein content of each of the four classes of sides were compared with the protein content as calculated from the curve, for the designated percentage of fat (Table 6).

TABLE 6.—*Accuracy of estimation of protein from fat*

Number of analyses	Straight averages		Calculated protein	Difference
	Fat	Protein		
	Per cent	*Per cent*	*Per cent*	*Per cent*
17	14.0	18.9	18.8	−0.1
16	21.4	17.5	17.6	+0.1
15	29.1	16.0	16.1	+0.1
6	46.6	11.5	11.7	+0.2

In the case of the loin and the round, analytical curves of the same type were used for estimating the protein. For several of the other cuts curves of similar form were drawn by inspection.

Primarily these curves were drawn as a step in the development of a method for deriving figures on the composition of typical cuts of beef, but they have brought out the following points of interest

quite apart from the method. The regression line for protein in the sides (fig. 6) does not fit the data at the upper end of the curve; the plotted points and the analytical curve lie below the straight line. This means that there is less protein (N $\times$ 6.25) in the thinner carcasses than would be expected on the assumption that the "fat-free" portion of meat is constant in composition. It has been shown (*8, 13*) that the proportion of nitrogen on a "fat-free" basis is a function of the age in immature animals. It appears from these data that it is also a function of the degree of fatness in mature beef animals.

The curves for protein in the loin, round, rib, and "lean meat" are of the same general shape but are not identical with the one for the sides. In each of them there is a marked curvature and the upper end indicates a relatively lower percentage of protein. In the cases of the round and the "lean meat" the protein at the upper end of the curve is distinctly lower than would have been estimated from a single straight line corresponding to the regression line for the entire side. On the other hand, the relation of protein to fat in the flank, plate and brisket, shin and shank, and "visible fat" is apparently a linear one, and in these cuts the protein is, if anything, high as compared with the protein estimated from the regression line for sides. The terms "lean meat" and "visible fat" used in this connection refer to those portions of certain cuts, principally loin, rib, and round. It must be remembered that the regression line for protein in the sides would fit all cases if the theory of constant composition on a "fat-free" basis could be applied with accuracy to separate tissues of beef. Variations from this line, then, are significant; they suggest a modification of that theory.

The fact that the upper end of the curves of certain cuts indicate relatively low percentages of protein when due allowance has been made for the fat content means that for these parts the ratio of water to crude protein must be higher. The protein curves for the flank and the "visible fat," which are distinctly above the regression line for protein in the sides, indicate a relatively high proportion of protein, and consequently a lower ratio of water to crude protein. This is not surprising, of course, considering that in these parts there is a much greater proportion of the protein in connective tissue. Calculating water by difference and computing the relation of water to crude protein gives a ratio of about 3.7 : 1 for "lean meat" when the fat is 5 per cent and 3.0 : 1 or less for all the points up to 70 per cent fat on the "visible fat" curve, whereas for sides the mean ratio is 3.45 : 1. It seems probable that these variations are related to the variation in the proportion of nitrogen in soluble form to total nitrogen.

The estimation of ash is somewhat less accurate in most cases than than that of protein, but there are enough data to show another slight modification of the theory of constant composition on a "fat-free" basis. If this theory were applied to the ash in the edible portion it would mean that the ratio of ash to protein must be constant for all degrees of fatness and that the regression line for ash should be parallel to that for protein, when they are plotted on suitable scales. It is apparent from Figures 6 and 10 that the regression line for ash crosses the one for protein. The scale is such that the lines would be superimposed if the estimate for ash were uniformly

5 per cent of the protein. The mean ratio of ash to protein for all of the sides is 0.0499 : 1, whereas the calculated ratio according to the estimating curve at 8 per cent fat is 0.0528 : 1. This is not a large variation, but it indicates a well-defined tendency for the ratio to be higher with the higher percentages of protein. The mean ash-protein ratio for "lean meat" is 0.0493 : 1 and for "visible fat," 0.0413 : 1.

ESTIMATION OF BONE

The relation between the percentages of bone in the sides and that of fat in the edible portion is shown in Figure 12. Percentages of bone were plotted against those of fat, the latter based on the edible portion.

It is evident that the relation of bone to fat is not so close as that of protein or ash to fat. The free-hand curve gives an index of correlation of 0.83 and a standard error of estimate of 1.83. The latter figure is given in the same terms as the estimate—that is, in percentage of bone in the entire side, lean, fat, and bone. This is equivalent to errors of about 11 and 12 per cent in the medium and fat classes, respectively, when the error is considered in terms of percentage of the estimate. Plainly this gives only a very rough estimate of the bone in any single side of beef, although it is appreciably better

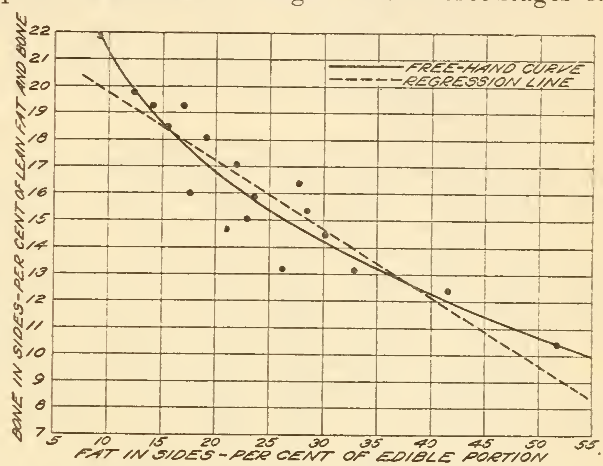

FIG. 12.—Relation of content of bone in per cent of lean, fat, and bone to that of fat (ether extract) in per cent of edible portion of the sides. The wide range of variation prevents any high degree of accuracy in estimation. The advantage of the free-hand curve over the straight line is apparent. Dots represent averages of three analyses

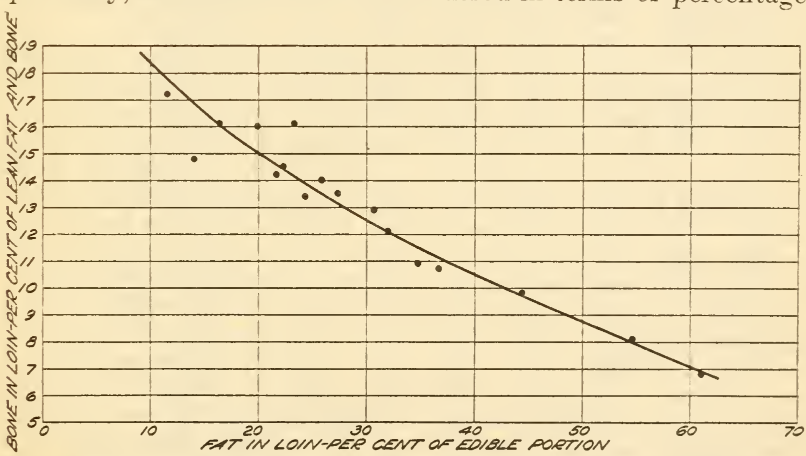

FIG. 13.—Relation of content of bone in per cent of lean, fat, and bone to that of fat (ether extract) in per cent of edible portion of the whole loin. A free-hand curve is used. Dots represent averages of three analyses

than one based on the regression line which gives a coefficient of correlation of −0.79 and a standard error of 2.02 per cent. The latter value is comparable with the figure of 1.83 from the curve. The free-hand curve was used in deriving the figures for bone in the sides. The various cuts were handled similarly (fig. 13).

INTERPRETATION OF FIGURES ON THE PROXIMATE COMPOSITION OF WHOLESALE CUTS

The results of most of the calculations on wholesale cuts are assembled in Table 7. All of these figures are relative in the sense that all of the ones for the thin cuts, for instance, refer to the composition of these particular cuts in a typical animal of the common grade. Relatively, the thin loin is as thin as the thin round, although the former has 16 per cent and the latter 8 per cent fat in the edible portion.

The figures for bone are percentages on the "as purchased" basis, which includes the entire wholesale cut, lean, fat, and bone; bone and gristle are considered together under this heading.

All of the percentages in the columns under "edible portion" are based on that portion, the lean meat and the visible fat, of the wholesale cut. In order to apply any of these figures to the "as purchased" basis, they must of course be converted by the proper factor, which is obtained by subtracting the percentage of bone from 100.

The degree of accuracy of the figures on wholesale cuts (Table 7) was considered in deciding whether they should be given in decimals, whole numbers, or round numbers. Because of the high order of variation, bone, water, fat, and visible fat are stated in whole numbers. Energy value is given to the nearest 10 calories. For any given percentage of fat the estimate of protein is probably good to better than 1 per cent of the edible portion and that of ash to better than one-tenth of a per cent; these estimates are given therefore to tenths and hundredths, respectively.

In order to make sure that the error in estimating the fat content of a particular wholesale cut is within 1 or 2 per cent as based on the edible portion, some kind of analysis of that cut is needed. A careful dissection of the cut into lean, fat, and bone provides a basis for a fairly close estimate of the fat as ether extract by interpolation from Table 8; and that in turn provides the basis for estimating protein, ash, and calories. This physical analysis is not difficult and may be made in the laboratory when it is important to estimate chemical composition with as much accuracy as possible without chemical analysis. If no such method as this is used, and it is assumed that the typical figures for a given class may be used for any cut within that class, the possible error in calculation should be considered.

An error of 10 per cent in the fat content of the edible portion is equivalent roughly to one of 2.2 per cent in protein, of 0.12 per cent in ash, and of about 370 calories per pound. In the application of these figures to particular wholesale cuts it would be unusual to make an error of such an order in estimating the fat content, except where figures for the medium class for example were applied to a wholesale cut that really belonged to one of the other classes. If the given cut were first classified as to fatness on the basis of the commercial grade of the carcass, such a possibility would be small.

The errors just discussed should be understood as errors that would be possible in the application of these or any other typical figures to individual cases. As averages of the composition of typical untrimmed wholesale cuts of the various classes the errors in the figures in Table 7 may be regarded as small.

TABLE 7.—*Proximate composition of untrimmed typical wholesale cuts of beef of four classes*

Cut	Class	As purchased	Edible portion					
				Chemical composition				
		Bone	"Visible fat"	Water	Protein (N× 6.25)	Fat (ether extract)	Ash	Fuel value per pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Chuck	Thin	19	8	71	19.2	9	0.94	720
	Medium	17	13	65	18.6	16	0.88	990
	Fat	15	17	60	17.6	22	0.82	1,220
	Very fat	13	24	52	15.0	32	0.74	1,580
Flank	Thin	1	40	52	17.0	30	0.77	1,530
	Medium	1	49	45	14.6	40	0.64	1,900
	Fat	1	56	39	12.7	48	0.54	2,190
	Very fat	1	68	28	9.3	62	0.36	2,700
Kidney	All classes	0	0	76	15.0	8	1.08	600
Kidney fat	Thin	0	100	9	3.0	88	0.16	3.650
	Medium	0	100	5	1.7	93	0.12	3,830
	Fat	0	100	4	1.5	94	0.11	3,860
	Very fat	0	100	4	1.5	94	0.11	3,860
Loin	Thin	16	15	64	18.6	16	0.95	990
	Medium	14	24	57	16.9	25	0.84	1,330
	Fat	12	30	53	15.6	31	0.77	1,550
	Very fat	10	41	44	12.8	43	0.62	1,990
Neck	Thin	27	12	69	19.1	11	0.92	800
	Medium	26	17	62	18.2	19	0.85	1,110
	Fat	25	22	57	17.0	25	0.80	1,330
	Very fat	24	29	50	14.0	35	0.71	1,680
Plate and brisket	Thin	22	17	60	17.9	21	0.87	1,180
	Medium	18	27	53	15.8	30	0.75	1,510
	Fat	15	34	47	14.0	38	0.65	1,810
	Very fat	11	47	38	11.0	51	0.48	2,280
Rib	Thin	25	8	66	19.0	14	0.94	920
	Medium	21	18	59	17.4	23	0.83	1,250
	Fat	18	24	52	15.8	31	0.74	1,550
	Very fat	14	38	43	12.7	44	0.59	2,030
Round	Thin	12	8	71	19.7	8	1.00	680
	Medium	11	13	67	19.3	13	0.95	880
	Fat	10	16	63	18.7	17	0.90	1,030
	Very fat	9	22	58	17.4	24	0.82	1,300
Rump	Thin	27	25	60	17.4	22	0.88	1,210
	Medium	24	33	53	15.5	31	0.77	1,550
	Fat	22	39	48	14.2	37	0.69	1,770
	Very fat	19	50	40	11.4	48	0.56	2,170
Shank, fore	Thin	41	7	72	21.0	6	0.98	630
	Medium	41	10	70	20.4	9	0.94	740
	Fat	40	12	67	19.7	12	0.90	850
	Very fat	38	18	63	18.2	18	0.83	1,070
Shank, hind	Thin	59	8	71	20.8	7	0.96	660
	Medium	59	12	69	20.1	10	0.93	770
	Fat	57	17	66	19.2	14	0.88	920
	Very fat	55	26	59	17.1	23	0.76	1,250
Sides	Thin	19	14	66	18.8	14	0.97	910
	Medium	16	21	60	17.5	22	0.87	1,220
	Fat	15	27	55	16.3	28	0.79	1,440
	Very fat	12	38	47	13.7	39	0.65	1,840

VARIATION IN RETAIL CUTS

All of the estimates up to this point were made on untrimmed wholesale cuts, and the figures do not apply directly therefore to meat as it comes to the consumer from the retail market. For the revision of Office of Experiment Stations Bulletin 28 (*1*) the figures for trimmed retail cuts are the more important. The method of handling the data on retail cuts was developed for the purpose of this revision and is outlined here; the detailed results are not included.

It is obvious that general estimates of composition must be less accurate for retail than for wholesale cuts, because the practice of cutting and of trimming meat in the retail market varies so widely. Further difficulty in obtaining satisfactory figures was presented by the fact that no chemical analyses of retail cuts could be found which were reported with the wholesale cuts or the sides of the same animal. Data on the physical composition of trimmed and untrimmed retail cuts were available, however, from the six carcasses analyzed by Hall and Emmett (*6*) and by Edinger (*4*). Though these data by themselves did not provide material for much generalization they could be used as the basis for fairly good estimates of the composition of certain types of retail cuts by relating them to the data on wholesale cuts.

The treatment of the data on retail cuts may be illustrated by the methods applied to those on retail loin cuts. Some idea of the order of variation in the composition of the trimmed cuts may be obtained by an examination of Table 8.

TABLE 8.—*Variations in the physical composition of trimmed retail loin cuts from six carcasses of beef*

Carcass	Visible fat in edible portion						Bone in cut "as purchased"					
	Untrimmed	Trimmed retail cuts					Untrimmed	Trimmed retail cuts				
	Whole loin	All loin cuts			Porterhouse	Sirloin	Whole loin	All loin cuts			Porterhouse	Sirloin
	Average	Average	Highest	Lowest	Average	Average	Average	Average	Highest	Lowest	Average	Average
HALL AND EMMETT	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	31.3	26.1	35.3	12.7	30.4	21.5	8.4	7.4	12.4	2.2	8.1	6.6
2	31.5	24.2	34.7	15.6	30.0	17.7	8.8	8.2	16.3	2.0	8.6	7.8
3	42.8	30.1	38.6	23.3	33.5	27.0	9.4	8.4	15.5	3.1	9.1	7.8
EDINGER												
A	41.0	34.3	52.6	20.4	41.9	28.7	11.0	8.0	15.6	2.3	9.1	7.2
B	32.3	25.6	44.4	11.4	30.8	20.6	13.4	10.9	20.0	4.5	12.7	9.1
C	14.9	13.0	20.0	5.9	13.8	12.5	17.8	13.0	41.2	5.0	17.3	10.4

It is apparent from Table 8 that no one figure for fat content will apply to all the trimmed loin cuts, since those cuts from a single animal, for example B in Edinger's group, may vary in their edible portion from 11 to 44 per cent visible fat. There was almost as wide a range in fat content in the porterhouse and in the sirloin as there was in the entire loin, although separate calculations for porterhouse

and sirloin steaks from the six carcasses showed that "on the average" porterhouse was higher in fat and in bone content than sirloin. For these reasons, figures for the composition of these two subdivisions of the loin and for the expected range among the loin cuts were derived. Percentages of visible fat were based on the edible portion and percentages of bone on the whole retail cut. The figures in Table 8 were plotted against assumed rather than determined values for the content of fat in the sides for the curves shown in Figures 14 and 15. The straight line estimate of the visible fat in the whole untrimmed loin was established by calculation from the lines in Figures 3 and 5. As this line was based on a larger number of observations it gives a better estimate of what is typical for wholesale loins than the six whole loins in question could give. It was used to reduce some of the errors due to variation in the smaller number.

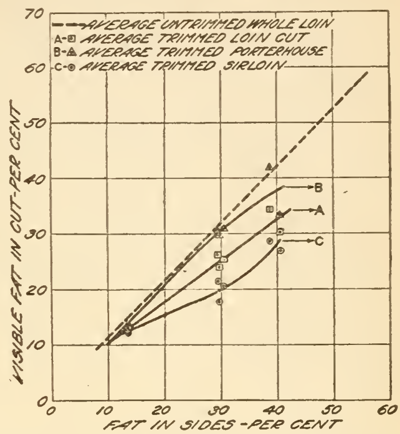

FIG. 14.—Relation of content of visible fat in the average of the edible portion of all the trimmed retail loin cuts (A) and of that portion of the trimmed porterhouse (B) and sirloin (C) cuts to the content of fat as ether extract in the edible portion of the sides. The estimating line (dotted) for untrimmed whole loin is determined from Figures 3 and 5. The visible fat content of the untrimmed cut is made the basis for assuming a value for the fat (ether extract) content of the sides, and the visible fat content of the trimmed cut (from Table 8) is plotted against this assumed value, which is used to reduce some of the individual variation

For any given class of beef it was possible to estimate roughly from Figure 14 the average content of visible fat in all the trimmed loin cuts as well as that in the porterhouse or the sirloin, and from Figure 15 the expected range of fat content for all the trimmed retail loin cuts was estimated. For a medium side of beef containing 22 per cent fat as ether extract, judging by these curves, it was expected that the trimmed loin cuts would range from about 9 to about 30 per cent visible fat and average, porterhouse, and sirloin cuts, trimmed, were estimated as containing, respectively, about 19.4, 22.7, and 16.4 per cent visible fat. Bone content was estimated similarly by graphic methods.

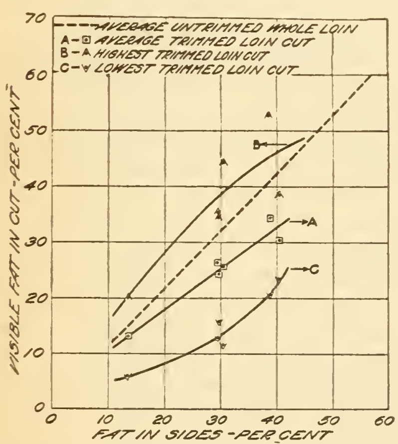

FIG. 15.—Relation of content of visible fat in the average of the edible portion of all the trimmed retail cuts (A) and of the highest (B) and lowest (C) percentages of fat in that portion of the same cuts (from Table 8) to the content of fat as ether extract in the edible portion of the sides. Assumed values for the fat content of the sides are used as in Figure 14

The process of calculating the content of fat as ether extract from the percentage of visible fat was not so simple for most of the retail cuts as it was for wholesale. The curves that related visible fat to fat as ether extract such as the one shown in Figure 5 were based on wholesale cuts and did not apply with any high degree of accuracy to the trimmed cuts. But for many of the cuts separate estimates

were made for the lean meat and the visible fat from a set of curves, such as those given for loin in Figure 4. These curves gave a much sounder basis for obtaining figures for ether extract from the content of visible fat in retail cuts than the kind shown in Figure 5. The estimation of the content of fat as ether extract in an average medium fat sirloin steak, for example, was made as follows: The visible fat in an average sirloin cut from a medium fat carcass (22 per cent fat as ether extract) was estimated from Figure 14 as 16.4 per cent of the edible portion. Of this part according to Figure 4 it was estimated that 79.8 per cent is fat as ether extract. The ether extract from the visible fat was considered equivalent therefore to 13.1 per cent (79.8 per cent of 16.4) of the edible portion. The percentage of lean meat in the edible portion was taken as 83.6, since the percentage of visible fat in that portion had already been estimated as 16.4; and the lean meat was estimated from Figure 4 as having 8.5 per cent fat as ether extract which is equivalent to 7.1 per cent of the edible portion. The entire edible portion therefore was calculated as having the sum of 13.1 and 7.1 per cent, or 20.2 per cent, fat as ether extract.

By the same method the approximate content of fat as ether extract in any other retail loin cut could be calculated if the percentage of visible fat in that cut and the approximate degree of fatness of the entire carcass are known. This means of calculating the fat as ether extract from the content of visible fat was not nearly so simple and direct as the method employed on wholesale cuts, but for retail cuts it is thought to be more nearly accurate than the short one. The curves relating visible fat to ether extract represented that relation for wholesale cuts at various stages of development and they embody changes therefore not only in the physical composition but in the chemical composition of the lean meat and the visible fat.

A different set of conditions has to be taken into account, however, in dealing with the retail cuts. The reason for adopting the more elaborate method in this case may be stated as follows: There is no basis for assuming that from any one wholesale cut the leanest trimmed retail cut has less fat as ether extract in its lean or in its visible fat than the fattest one. The principal difference in the composition of the edible portion between the leanest and the fattest steak from any particular loin for example is presumably due to a difference in the proportion of visible fat. Similiarly, the difference between the trimmed and the untrimmed cuts from a certain loin is mainly a matter of physical composition. Trimming off some of the visible fat obviously does not affect the chemical composition of its lean meat and it is a fair enough assumption that the composition of the remaining visible fat is not very different from that of the visible fat in the untrimmed cut. If the trimming has changed the proportion of visible fat materially, therefore, it would introduce a considerable error to calculate the ether extract from the visible fat in the trimmed cut from the same curve as the untrimmed.

On account of the nature of the data it was impossible to apply uniform treatment to all of the retail cuts. In some cases, such as the round, the shin, and the shank, it was impracticable to subdivide the wholesale cut except to give figures for the composition of the average of all the cuts and ones for the cuts having the highest and lowest percentages of visible fat and of bone. In the cases of other wholesale cuts, such as the rib and the flank, two or three principal

subdivisions of the whole cut were calculated, and no basis for further indication of range of variation was provided.

For some wholesale cuts there were no separate figures available for the composition of the lean meat or of the visible fat, and in such cases it was necessary to derive the figures for fat as ether extract directly from the ones for visible fat by means of the curves that relate visible fat in the wholesale cut to fat as ether extract. Such a derivation introduces serious errors only when the particular retail cut to be calculated differs widely in its content of visible fat from that of the wholesale cut.

The protein and ash curves for the wholesale cuts were used to obtain estimates of the percentages of these constituents in the retail cuts. Probably for a given percentage of fat as ether extract these estimates were fairly close. There were smaller errors introduced by this step in the calculation, almost certainly, than by the previous one, that of estimating fat as ether extract from the content of visible fat.

SUMMARY

An improved method based on statistical analysis has been developed for deriving figures for the proximate composition of cuts of beef. Greater accuracy is possible in dietary calculations from figures derived in this way than from ones derived by the method of straight averages used previously.

Without some method of estimating the percentage of fat in a particular cut large errors may be introduced into estimates of its composition and its fuel value.

An approximate relation between commercial grade and fat content of beef has been established.

For any given wholesale cut there is a close relation between the content of fat determined as ether extract and that of visible fat. This relation provides a basis for making fairly close estimates of the chemical composition of any wholesale cut from a determination, by dissection, of the percentage of visible fat. Such estimates may be made from Table 7 on the composition of wholesale cuts.

The protein content of the edible portion of the wholesale cuts as well as of the sides can be estimated from their fat content with reasonable accuracy. The relation between protein and fat is not the same, however, for the various wholesale cuts, and these differences are significant.

The protein content of the edible portion of fresh mature beef sides is a curvilinear function of the fat content. This may be considered as a modification of the theory of constant composition of "fat-free" mature beef.

The ash content, as a linear function of the fat content, can be estimated for sides or wholesale cuts with fair accuracy.

The bone content of the entire side or of certain standard wholesale cuts may be estimated roughly from the fat content, but there is too much variation in bone content to permit of much accuracy in such an estimation.

Estimating the chemical composition of beef is more difficult and less accurate for retail than for wholesale cuts. The grade or class of beef and the type of cut, as well as its proportion of lean meat, visible fat, and bone must be known if a close estimate is required.

LITERATURE CITED

(1) Atwater, W. O., and Bryant, A. P.
1899. THE CHEMICAL COMPOSITION OF AMERICAN FOOD MATERIALS. U. S. Dept. Agr., Off. Exp. Sta. Bul. 28, 87 pp., illus.

(2) Davis, W. C.
1924. COMMERCIAL CUTS OF MEAT. U. S. Dept. Agr., Dept. Circ. 300, 10 pp., illus.

(3) ——— and Whalin, C. V.
1924. MARKET CLASSES AND GRADES OF DRESSED BEEF. U. S. Dept. Agr., Dept. Bul. 1246, 48 pp., illus.

(4) Edinger, A. T.
1925. THE PHYSICAL COMPOSITION OF A LEAN, A HALF FAT, AND A FAT BEEF CARCASS AND THE RELATIVE COST OF THE NUTRIENTS CONTAINED IN EACH. Mo. Agr. Exp. Sta. Research Bul. 83, 63 pp., illus.

(5) Francis, C. K., and Trowbridge, P. F.
1910. PHOSPHORUS IN BEEF ANIMALS. PART I. Jour. Biol. Chem. 7: 481–501.

(6) Hall, L. D., and Emmett, A. D.
1912. RELATIVE ECONOMY, COMPOSITION AND NUTRITIVE VALUE OF THE VARIOUS CUTS OF BEEF. Ill. Agr. Exp. Sta. Bul. 158: 135–233, illus.

(7) Jordan, W. H.
1896. THE RELATION OF FOOD TO THE GROWTH AND COMPOSITION OF THE BODIES OF STEERS. Me. Agr. Exp. Sta. Ann. Rpt. 1895: 36–77.

(8) Moulton, C. R.
1923. AGE AND CHEMICAL DEVELOPMENT IN MAMMALS. Jour. Biol. Chem. 57: 79–97, illus.

(9) ———, Trowbridge, P. F., and Haigh, L. D.
1921. STUDIES IN ANIMAL NUTRITION. I. CHANGES IN FORM AND WEIGHT ON DIFFERENT PLANES OF NUTRITION. Mo. Agr. Exp. Sta. Research Bul. 43, 111 pp., illus.

(10) ———, Trowbridge, P. F., and Haigh, L. D.
1922. STUDIES IN ANIMAL NUTRITION. II. CHANGE IN PROPORTIONS OF CARCASS AND OFFAL ON DIFFERENT PLANES OF NUTRITION. Mo. Agr. Exp. Sta. Research Bul. 54, 76 pp., illus.

(11) ———, Trowbridge, P. F., and Haigh, L. D.
1922. STUDIES IN ANIMAL NUTRITION. III. CHANGES IN CHEMICAL COMPOSITION ON DIFFERENT PLANES OF NUTRITION. Mo. Agr. Exp. Sta. Research Bul. 55, 88 pp., illus.

(12) ———, Trowbridge, P. F., and Haigh, L. D.
1923. STUDIES IN ANIMAL NUTRITION. V. CHANGES IN THE COMPOSITION OF THE MATURE DAIRY COW WHILE FATTENING. Mo. Agr. Exp. Sta. Research Bul. 61, 20 pp.

(13) Rubner, Max.
1924. THE RELATION BETWEEN THE COLLOIDAL CONDITION OF TISSUES AND GROWTH. Trans. Biochem. Ztschr. 148: 187–221, illus.

(14) Spillman, W. J.
1923. APPLICATION OF THE LAW OF DIMINISHING RETURNS TO SOME FERTILIZER AND FEED DATA. Jour. Farm Econ. 5: 36–52, illus.

(15) ——— and Lang, E.
1924. THE LAW OF DIMINISHING RETURNS. 178 pp., illus. New York.

(16) Trowbridge, P. F., Moulton, C. R., and Haigh, L. D.
1918. EFFECT OF LIMITED FOOD SUPPLY ON THE GROWTH OF YOUNG BEEF ANIMALS. Mo. Agr. Exp. Sta. Research Bul. 28, 129 pp., illus.

(17) ———, Moulton, C. R. and Haigh, L. D.
1919. COMPOSITION OF THE BEEF ANIMAL AND ENERGY COST OF FATTENING. Mo. Agr. Exp. Sta. Research Bul. 30, 106 pp., illus.

ORGANIZATION OF THE
UNITED STATES DEPARTMENT OF AGRICULTURE

July 6, 1926

Secretary of Agriculture	W. M. Jardine.
Assistant Secretary	R. W. Dunlap.
Director of Scientific Work	———
Director of Regulatory Work	Walter G. Campbell.
Director of Extension Work	C. W. Warburton.
Director of Information	Nelson Antrim Crawford.
Director of Personnel and Business Administration	W. W. Stockberger.
Solicitor	R. W. Williams.
Weather Bureau	Charles F. Marvin, *Chief.*
Bureau of Agricultural Economics	Lloyd S. Tenny, *Acting Chief.*
Bureau of Animal Industry	John R. Mohler, *Chief.*
Bureau of Plant Industry	William A. Taylor, *Chief.*
Forest Service	W. B. Greeley, *Chief.*
Bureau of Chemistry	C. A. Browne, *Chief.*
Bureau of Soils	Milton Whitney, *Chief.*
Bureau of Entomology	L. O. Howard, *Chief.*
Bureau of Biological Survey	E. W. Nelson, *Chief.*
Bureau of Public Roads	Thomas H. MacDonald, *Chief.*
Bureau of Home Economics	Louise Stanley, *Chief.*
Bureau of Dairying	C. W. Larson, *Chief.*
Fixed Nitrogen Research Laboratory	F. G. Cottrell, *Director.*
Office of Experiment Stations	E. W. Allen, *Chief.*
Office of Cooperative Extension Work	C. B. Smith, *Chief.*
Library	Claribel R. Barnett, *Librarian.*
Federal Horticultural Board	C. L. Marlatt, *Chairman.*
Insecticide and Fungicide Board	J. K. Haywood, *Chairman.*
Packers and Stockyards Administration	John T. Caine III, *in Charge.*
Grain Futures Administration	J. W. Duvel, *in Charge.*

This circular is a contribution from

Bureau of Home Economics ---------- Louise Stanley, *Chief.*

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
▽